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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

9319S-000062

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5)

N/A 09/068270

INTERNATIONAL APPLICATION NO.
PCT/JP97/03115

INTERNATIONAL FILING DATE
September 4, 1997

PRIORITY DATE CLAIMED
September 5, 1996

TITLE OF INVENTION

Semiconductor Device Connecting Structure, Liquid Crystal Display Unit Based On The Same Connecting Structure,
And Electronic Apparatus Using The Same Display Unit

APPLICANT(S) FOR DO/EO/US

Kenji UCHIYAMA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☐ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☒ Certificate of Mailing by Express Mail
19. ☒ Other items or information:

Form PTO-1449 with copies of the references cited therein (3 Japan); and 6 sheets of drawings showing FIGS. 1-8.

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Attorney Docket 9319S-000062

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Kenji Uchiyama)
)
International)
Application No. PCT/JP97/03115)
)
International)
Filing Date: September 4, 1997)
)
For: Semiconductor Device Connecting Structure,)
Liquid Crystal Display Unit Based on the Same)
Connecting Structure, and Electronic Apparatus)
Using the Same Display Unit)
_____)

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents & Trademarks
Washington, D.C. 20231

CERTIFICATE OF EXPRESS MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as express mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on May 4, 1998

By [Signature]

Sir:

Prior to the examination of this application, please amend it as follows:

IN THE SPECIFICATION

Page 1, line 13, please delete "potable" and substitute --portable-- therefor.

Page 3, line 3, please delete "wraps" and substitute --warps-- therefor.

Page 3, line 6, please delete "directly" and substitute --direct-- therefor.

Page 3, line 18, please delete "join in between" and substitute --bond-- therefor.

Page 4, line 9, after "according", please insert --to--.

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Page 6, line 6, after "In", please insert --the--.

Page 6, line 9, after "in", please insert --the--.

Page 6, line 22, please delete "directions" and substitute --direction-- therefor.

Page 6, line 24, please delete "directions" and substitute --direction-- therefor.

Page 6, line 24, before "ring-shape", please insert --a--.

Page 7, line 2, please delete "directions" and substitute --direction-- therefor.

Page 7, line 3, please delete "directions" and substitute --direction-- therefor.

Page 7, line 19, please delete "substrate," and substitute --substrate.-- therefor.

Page 7, line 20, please delete "on" and substitute --of-- therefor.

Page 8, line 17, please delete "space (s)," and substitute --space(s),-- therefor.

Page 9, line 1, please delete "for liquid crystal".

Page 9, line 4, please delete "for liquid crystal".

Page 9, line 6, please delete "for liquid crystal".

Page 9, line 8, please delete "for liquid crystal".

Page 10, line 1, please delete "semiconductor" and insert --semiconductors-- therefor.

Page 10, line 4, please delete "for liquid crystal".

Page 10, lines 8-10, please delete "a bonding layer placed between the substrates for liquid crystal and".

Page 10, line 20, please delete "plane" and substitute --plan-- therefor.

Page 10, line 21, please delete "according to an" and substitute --at-- therefor.

Page 11, line 13, please delete "plane" and substitute --plan-- therefor.

Page 11, line 15, please delete "plane" and substitute --plan-- therefor.

Page 12, line 11, please delete "in".

Page 12, line 15, please delete "the".

Page 14, line 1, please delete "takes" and substitute --provides-- therefor.

Page 15, line 19, please delete "directions" and substitute --direction-- therefor.

Page 16, line 17, please delete "Owing" and substitute --Due to-- therefor.

Page 18, line 4, please delete "directions" and substitute --direction-- therefor.

Page 18, line 5, please delete "directions" and substitute --direction-- therefor.

Page 18, line 10, after "as", please insert --where--.

Page 19, line 10, please delete "prevent" and substitute --prevented-- therefor.

Page 21, line 5, after "electrodes)", please insert --to--.

Page 21, line 17, please delete "directions" and substitute --direction-- therefor.

Page 21, line 18, please delete "directions" and substitute --direction-- therefor.

Page 22, line 3, please delete "or" and substitute --and-- therefor.

Page 22, line 11, please delete "directions" and substitute --direction-- therefor.

Page 22, line 18, please delete "can be covered" and substitute --includes-- therefor.

IN THE CLAIMS

Please amend the claims as follows:

Before Claim 1, please insert "What is claimed is:"

Claim 1, line 5, please delete "therein," and substitute --therebetween,-- therefor.

Claim 2, line 6, before "areas", please insert --the--.

Claim 3, line 2, please delete "or 2".

4. (AMENDED) A semiconductor device connecting structure as defined in [any one of claims 1 to 3] Claim 1, characterized in that said bonding material is an anisotropic conductive film formed by dispersing conductive particles into a resin film.

Claim 8, line 5, please delete "therein," and substitute --therebetween,-- therefor.

Claim 9, line 5, please delete "therein;" and substitute --therebetween;-- therefor.

Claim 11, line 4, please delete "between;" and substitute --therebetween;-- therefor.

Claim 11, line 9, please delete "therein," and substitute --therebetween,-- therefor.

Claim 12, line 5, after "one of", please insert --the--.

Claim 13, line 1-2, please delete "or 12".

14. (AMENDED) A liquid crystal display unit as defined in [any one of claims 11 to 13] Claim 11, characterized in that said bonding material is an anisotropic conductive film formed by dispersing conductive particles into a resin film.

Claim 17, line 8, please delete "between;" and substitute --therebetween;-- therefor.

Claim 17, line 13, please delete "therein," and substitute --therebetween,-- therefor.

IN THE ABSTRACT

Page 28, line 1, after "structure", please insert --is provided--.

Page 28, line 4, please delete "therein." and insert --therebetween.-- therefor.

REMARKS

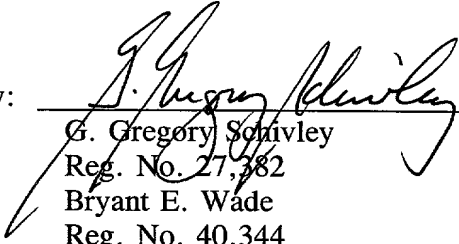
The purpose of this preliminary amendment is to clarify the application as originally filed and to eliminate multiple dependent claims to reduce filing costs.

Favorable consideration of this application is respectfully requested.

Respectfully submitted,

Date: May 4, 1998

By:


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SPECIFICATION

SEMICONDUCTOR DEVICE CONNECTING STRUCTURE, LIQUID CRYSTAL
DISPLAY UNIT BASED ON THE SAME CONNECTING STRUCTURE, AND
ELECTRONIC APPARATUS

USING THE SAME DISPLAY UNIT

[TECHNICAL FIELD]

The present invention relates to a semiconductor device connecting structure for connecting a semiconductor device onto a substrate (or board), a liquid crystal display unit based upon the semiconductor device connecting structure, and an electronic apparatus using the liquid crystal display unit.

[BACKGROUND ART]

In recent years, liquid crystal display units for displaying visible information have come into widespread use for electronic equipment such as navigation systems, televisions, palm-top computers, electronic organizers and portable telephones. In general, these liquid crystal display units are constructed such that a liquid crystal driving IC, i.e., a semiconductor device, is connected to a liquid crystal panel and incidental parts such as a back light and a casing are mounted on the liquid crystal panel.

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This liquid crystal panel is commonly made in a manner that a liquid crystal is put in between at least two substrates for the liquid crystal, and a polarizing plate, a color filter and others are mounted when necessary.

Many kind of ways of the connection of the liquid crystal driving IC to the liquid crystal panel have been considered, for example, connecting methods based upon a COB (Chip On Board) method, a COG (Chip On Glass) method or the like. According to the COB method, the liquid crystal driving IC is joined through the use of an ACF (Anisotropic Conductive Film) or other joining materials to an insulating substrate having a wiring pattern thereon, and that insulating substrate is connected through a heat seal or the like to the liquid crystal panel.

On the other hand, according to the COG method, the liquid crystal driving IC is directly joined through the use of the ACF or the like to a glass substrate having electrode terminals. In both the COB method and the COG method, a semiconductor device such as the liquid crystal driving IC is connected onto the substrate such as the insulating substrate and the liquid crystal glass substrate.

In the above-mentioned prior connecting methods, the ACF or other joining materials are uniformly placed in between the substrate and the liquid crystal driving IC

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without making a space therein. For this reason, when the liquid crystal driving IC is joined thereto under pressure, wraps take place on the IC itself, or when the liquid crystal driving IC and/or the substrate deform due to the variation of temperature, excessive stresses occur at the bump portions of the liquid crystal driving IC in directly contact with the electrodes on the substrate. As a result, the electrical connecting conditions can become unstable. In addition, for avoiding such problems, the pressure-joining conditions for the liquid crystal driving IC are required to be severely managed within a small tolerance. As a result, a complicated process management is demanded.

Moreover, in the Japanese Unexamined Patent Publication No. 2-42738, there has been disclosed a connecting structure in which, in a COB based packaged printed-circuit board, a flexible bonding layer is placed as a cushioning material between an IC chip and a substrate to improve the reliability of the join in between. However, in the case of this prior connecting structure, it is required to provide the flexible bonding layer for exclusive use for the purpose of taking the cushioning action, which leads to higher component cost and manufacturing cost.

Accordingly, the present invention has been developed with a view to eliminating the problems which arise with the

prior semiconductor device connecting structure. The object of this invention is to maintain steadily the connecting condition of a semiconductor device to a substrate only by adding an extremely simple construction.

[DESCRIPTION OF THE INVENTION]

For the purpose described above, in accordance with the present invention, in a semiconductor device connecting structure for joining a semiconductor device onto a substrate according this invention, there is a bonding layer in between the substrate and the semiconductor device for adhesion of both of them. The bonding layer contains a bonding material for joining the semiconductor device to the substrate and a space(s) formed in the interior of the bonding material.

According to this connecting structure, the space(s) is specially made in the bonding material when conducting the adhesion between the semiconductor device and the substrate, and absorb the deformation of the semiconductor device and others, changing freely in shape in response to the deformation of the substrate or the semiconductor device. In consequence, even in the case of the deformation of the semiconductor device or the substrate, it is possible to prevent excessive loads from applying on the electrode

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portions of the semiconductor device, so that the electrical connecting condition of the semiconductor device can be maintained steadily in good condition.

The space(s) is formed in the bonding material by pressurizing an IC with a pressurizing head and by heating at the same time as described below. When the temperature of the pressurizing head is given to the bonding material, the viscosity of the bonding material rapidly decreases to flow out to the external. In this way the space(s) can be formed. Thus, by forming the space(s) in the bonding material, it is possible to relieve the deformation of the semiconductor device or the substrate.

In the structure described above, as the semiconductor device, an IC chip and an LSI chip can be considered. Further, when supposing a liquid crystal display unit, as the semiconductor device, a liquid crystal driving IC can be considered. As the substrate, an insulating substrate in the COB method, a transparent substrate for a liquid crystal in the COG method, and various substrates corresponding to other connecting methods can be considered. As the bonding material, an ACF (Anisotropic Conductive Film) and a common bonding material can be considered.

The ACF is produced by dispersing conductive particles into a thermoplastic film or a thermosetting resin film, and

is a bonding material showing the conductivity in a single direction by receiving the thermocompression bonding.

On the other hand, the common bonding materials have a function to join a semiconductor device to a substrate only mechanically, not electrically.

In case of using the ACF, the terminals on the substrate and the bumps of the semiconductor device are electrically coupled through the conductive particles to each other. On the contrary, in case of using the common bonding material, the terminals on the substrate and the bumps of the semiconductor device are directly connected to establish an electrical conduction, and in this state, the semiconductor device is mechanically joined to the substrate by the common bonding material.

Considering the liquid crystal driving IC to be used for a liquid crystal display unit as the semiconductor device, a plurality of bumps are arranged in rows on an active surface of the liquid crystal driving IC. Various ways can be considered for that in-row arrangement. For instance, as shown in Figs. 2 and 7, a pair of bump strings 28, 29 arranged in rows (two rows in the illustrations) in the longitudinal directions and a pair of bump strings 28, 28 arranged in rows (two rows in the illustrations) in the transverse directions are arranged in ring-shape. Further,

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as shown in Fig. 8, a pair of bump strings 28, 29 may be located only in the longitudinal directions or in the transverse directions.

For the connection of the semiconductor device with the foregoing bump arrangement onto the substrate, as shown in Fig. 2, spaces 33 are formed in an adhesive (bonding material) within an area surrounded by the ring-shaped arranged bumps, or as shown in Fig. 7, spaces 33 are formed between the respective bumps 28, 29 or outside the bump strings.

The spaces to be formed inside the adhesive can be made as a single space with a large volume, or can be made by disposing a plurality of spaces with small volumes in mutually close conditions.

Preferably, the space rate to the adhesive assumes between 5% and 70%, more preferably between 10% and 30%. This is because, in the case that the space rate is below 5%, it is impossible to absorb the deformation (or stress) of the semiconductor device or the substrate, On the contrary, when it assumes more than 70%, the reliability on the connection between the semiconductor device and the substrate (particularly, the terminals formed on the substrate) goes down. Accordingly, if the space(s) is formed at the rate of 5% to 70%, the connection reliability

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The bonding layer is made of an epoxy-based adhesive. Further, this bonding layer absorbs the deformation of the semiconductor device or the substrate.

A liquid crystal display unit according to this invention is a liquid crystal display unit with the above-described semiconductor device connecting structure. In more detail, the liquid crystal display unit according to

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this invention is composed of a pair of substrates for liquid crystal disposed in an opposed relation to each other to interpose a liquid crystal therein, a semiconductor device joined onto at least one of the substrates for liquid crystal, and a liquid crystal display apparatus with a bonding layer placed in between the substrate for liquid crystal and the semiconductor device to join the semiconductor device to the substrate for liquid crystal, wherein the bonding layer contains an adhesive for adhering the semiconductor device to the liquid crystal holding substrate and a space(s) made in the interior of the adhesive.

As mentioned above, it is preferable that the space rate to the adhesive is set to reach 5% to 70%, more preferably 10% to 30%, so that the semiconductor device and the electrode terminals formed on the substrate can be connected with a high reliability.

Moreover, concrete examples of an electronic apparatus using a liquid crystal display unit according to this invention are various kinds of equipment such as a navigation system, a television, a palm-top computer, an electronic organizer and a portable telephone. More specifically, one of the examples is the electronic apparatus with output terminals for driving a plurality of

semiconductor, a liquid crystal display unit connected to these output terminals for driving a semiconductor, and an input unit. The liquid crystal display unit includes a pair of substrates for liquid crystal disposed in an opposed relation to each other to interpose a liquid crystal therein, a semiconductor device joined onto at least one of the liquid crystal holding substrates, and a bonding layer placed in between the liquid crystal holding substrate and a bonding layer placed between the substrates for liquid crystal and the semiconductor device to join the semiconductor device to the substrates for liquid crystal. In this case, the bonding layer contains an adhesive for adhering the semiconductor device to the substrates for liquid crystal and a space(s) made in the interior of the adhesive.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 is a cross-sectional view showing an embodiment of a semiconductor device connecting structure according to the present invention;

Fig. 2 is a plane view showing a joining portion of a semiconductor device according to an arrow A in Fig. 1;

Fig. 3 is a side elevational cross-sectional view showing an embodiment of a liquid crystal display unit according to this invention;

Fig. 4 is an exploded perspective view of a liquid crystal display unit shown in the Fig.1;

Fig. 5 is a perspective view showing one example of elastic connectors for electrically connecting a liquid crystal display unit to another circuit inside of an electronic apparatus;

Fig. 6 is an exploded perspective view showing a portable telephone which is an embodiment of electronic apparatus according to an embodiment of this invention;

Fig. 7 is a plane view showing a modification of a way of forming spaces on an adhesive; and

Fig. 8 is a plane view showing a modification of a bump arrangement on a semiconductor device.

[DESCRIPTION OF THE BEST MODE OF CARRYING OUT THE INVENTION]

Fig. 6 shows a portable telephone as one example of electronic apparatus using a liquid crystal display unit according to an embodiment of the present invention. This portable telephone is equipped with an upper housing 1 and a lower housing 2. The upper housing 1 includes a PCB

(Printed Circuit Board) for controlling a keyboard 10. In addition, the lower housing 2 includes a control circuit board 3 mounting a control LSI and a body board 4 mounting the circuit board 3. A liquid crystal display unit 5 according to this invention is mounted on the body board 4. A plurality of semiconductor driving output terminals 6 are formed as a wiring pattern on the surface of the body board 4. The liquid crystal display unit 5 has a liquid crystal driving IC 7, i.e., a semiconductor device, therein. The liquid crystal driving IC 7 is electrically connected to the semiconductor driving output terminals 6 in with the liquid crystal display unit 5 mounted on the body board 4. The liquid crystal display unit 5 and other necessary units are placed within the lower housing 2 and subsequently the upper housing 1 is placed thereon from the above. In this way a portable telephone is completed. Incidentally, numeral 20 designates a speaker.

For instance, as shown in Fig. 4, the liquid crystal display unit 5 includes a liquid crystal panel 8, a back light unit 9, a shielded case 11 and an elastic connector 12. The liquid crystal panel 8 includes, as shown in Fig. 3, a first liquid crystal holding substrate 13 made of a transparent glass and a second liquid crystal holding substrate 14 made of a transparent glass. A transparent

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electrode 18 is formed on an inner surface of the first liquid crystal holding substrate 13, whereas a transparent electrode 19 is formed on an inner surface of the second liquid crystal holding substrate 14. Both electrodes are made of an ITO (Indium Thin Oxide) and another transparent conductive material.

Furthermore, polarizing plates 16a, 16b, serving as polarizing means, are adhered to outer surfaces of the first and second liquid crystal holding substrates 13, 14, respectively. The first liquid crystal holding substrates 13 and second liquid crystal holding substrates 14 are joined in a liquid-proof condition to each other by a ring-like sealing compound 17 with a certain gap, so-called cell gap. Further, a liquid crystal is sealed in the cell gap. A semiconductor input terminal 21 is formed at a right-hand end portion on an inner surface of a section 13a of the first liquid crystal holding substrate 13 protruding toward the exterior (the right side in Fig. 3) of the second liquid crystal holding substrate 14. The liquid crystal driving IC 7 as a semiconductor device is directly adhered by a bonding layer 31 onto the first liquid crystal holding substrate 13, whereupon an output bump 28 of the IC 7 is connected to the transparent electrode 18 while an input bump 29 of the IC 7 is connected to the semiconductor input terminal 21.

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Thus, this embodiment takes a liquid crystal display unit, that is, a COG (Chip On Glass) type liquid crystal display unit, where the liquid crystal driving IC 7 is directly joined to the liquid crystal holding substrate 13 constituting the liquid crystal panel 8.

In Fig. 3, the back light unit 9 comprises a light guiding member 22 and a plurality of (for example, 4) LEDs (Light Emitting Diodes) 23 fixed to a left-hand end portion of the light guiding member 22. Also, as shown in Fig. 4, a rectangular-parallelepiped-like guide hole 24 serving as a guide for the elastic connector 12 is made in a right-hand end portion of the light guiding member 22. As shown in Fig. 3, this guide hole 24 is made to have a dimension accepting the elastic connector 12 without making a gap.

The elastic connector 12 is, as shown in Fig. 5, equipped with an elastic material with an electrical insulation, for example, an elastic proximal section 25 made of a silicone rubber to have a cross-sectional semi-circular column-like configuration, and a large number of conductive sections 26 provided in parallel to each other on a semi-circular outer circumferential surface of the elastic proximal section 25. An elastic material is placed between the two conductive sections adjacent to each other to form a non-conductive section. The width of the non-conductive

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section is kept to be $15\ \mu\text{m}$ to $25\ \mu\text{m}$. In the illustration, reference mark W represents the separation between the adjacent conductive section 26, so-called inter-conductive-section pitch, which is commonly set to $W = 30\ \mu\text{m}$ to $50\ \mu\text{m}$.

For mounting the liquid crystal display unit according to this embodiment on the body board 4 of the portable telephone (Fig. 6), in Fig. 4, the elastic connector 12 is inserted into the guide hole 24 in the light guiding member 22, and the back light unit 9 is placed at a given position on the body board 4, and the liquid crystal panel 8 is placed at a given position on the back light unit 9, and the shielded case 11 is put on the liquid crystal panel 8 and the back light unit 9 in a state where a pressurizing member 30 made of a silicone rubber or another elastic material is interposed therein. And further, as shown in Fig. 3, the body board 4 and the shielded case 11 are tightened and fixed to each other by deforming a caulking stopper 27.

At this time, the elastic connector 12 is compressed and deformed elastically in the vertical directions due to the effect of the pressurizing member 30, whereupon the conductive sections 26 (see Fig. 5) firmly comes into contact with both the semiconductor input terminal 21 on the liquid crystal panel 8 side and the semiconductor driving output terminal 6 on the body board 4 side owing to the

Incidentally, in terms of the way of compressing the elastic connector 12, it is also possible that, in place of preparing a dedicated component such as the pressurizing member 30, the corresponding portion of the shielded case 11 is deformed to protrude inwardly to form a rib at that portion of the shielded case 11 so that the rib compresses the elastic connector 12.

In this embodiment, since only by disposing the elastic connector 12 between the semiconductor input terminal 21 on the liquid crystal panel 8 side and the semiconductor driving output terminal 6 on the portable telephone side, both of them can be electrically connected to each other, the assembling work becomes extremely easy. In addition,

since the elastic connector 12 is put within the guide hole 24, when a force works on the elastic connector 12, the elastic connector 12 warps without deformation such as buckling. Therefore, the electrical connecting condition between the semiconductor input terminal 21 and the semiconductor driving output terminal 6 can always be maintained steadily.

In this embodiment, as shown in Fig. 1, the liquid crystal driving IC 7 is adhered onto the first liquid crystal substrate 13 by the bonding layer 31. The bonding layer 31 is composed of an ACF (Anisotropic Conductive Film) 32 serving as an adhesive and a plurality of spaces 33 formed inside of the ACF 32. The ACF 32 is formed by dispersing a large number of conductive particles 34 into an adhesive-property resin film, and the output bump 28 of the IC 7 is electrically connected through the conductive particles 34 to the transparent electrode 18, whereas the input bump 29 is electrically connected through the conductive particles 34 to the semiconductor input terminal 21. Further, the bump 28, the bump 29 and the portions between the terminals are held in a insulated condition by an adhesive-property resin.

Fig. 2 shows the joining portion of the liquid crystal driving IC 7 viewed from the direction indicated by an arrow

A in Fig. 1. Obviously from the illustration, the plurality of spaces 33 are positioned to be close to each other within an area surrounded by the bumps 28, 29 arranged in two rows in the longitudinal directions and the bumps 28, 28 arranged in two rows in the transverse directions, that is, within an area surrounded by the plurality of bumps 28, 29 arranged to make a ring-like configuration. Incidentally, although Fig. 2 is illustrated with the bumps 28 and 29 omitted, bumps are formed at the circumferential end portions of the substrates as well as illustrated.

In general, for joining the liquid crystal driving IC 7 onto the substrate 13, the liquid crystal driving IC 7 is heated and pressed against the substrate 13 under a given pressure with the ACF 32 interposed between the IC 7 and the substrate 13. In this case, preferably, the ACF 32 is made of an epoxy-based adhesive. Particularly, if it is formed with a molecule including an epoxy radical at a relatively small molecular weight, an excellent adhesive property can be obtained.

At this heating and pressurizing processing, the liquid crystal driving IC 7 may warp, and when it warps, an excessive stress may occur in the connecting portions of the bumps 28 and 29, causing the electrically connecting condition to be unstable. Further, when the temperature

varies in the liquid crystal driving IC 7, the IC 7 and/or the substrate 13 may deform, causing the connecting conditions of the bumps 28 and 29 to be unstable.

On the other hand, if the spaces 33 are provided inside the ACF 32 like this embodiment, when the liquid crystal driving IC 7 deforms, the spaces 33 freely can deform in accordance with the deformation of IC7 and can absorb the deformation of the IC 7. As a result, the excessive stress on the connecting portions of the bumps 28, 29 can be prevented.

The way of forming the spaces 33 inside of the ACF 32 is not limited to a specific method. For example, if the pressure bonding condition for joining the liquid crystal driving IC 7 onto the substrate 13 is set to an appropriate condition for the liquid crystal driving IC to be used, the spaces 33 can be produced. The following requirements are listed as one example of the pressure-bonding condition.

(1) liquid crystal driving IC 7 : SED1220

(manufactured by Seiko Epson Co., Ltd.)

In Fig. 2, this IC has a dimension of $L \times W = 7.7 \text{ mm} \times 2.8 \text{ mm}$, and the number of bumps is approximately 200 and the bump size is $80 \text{ } \mu\text{m} \times 120 \text{ } \mu\text{m}$.

(2) ACF 32 : CP8530 (manufactured by Sony Chemical

Co., Ltd.)

(3) Heating temperature of ACF : 180 to 230°C (central temperature = 200 to 210°C)

In the case that the ACF is pressurized and heated by pressing the IC 7 with the pressurizing head heated up to a high temperature, if the temperature of the pressurizing head is set to 260 to 360°C (central temperature = approximately 300°C), the aforesaid ACF temperature can be obtained.

(4) Pressurizing force of pressurizing head : 12 kgf to 20 kgf

(5) Pressurizing time of pressurizing head : 10 seconds

When the liquid crystal driving IC 7 was joined to the substrate 13 under the aforesaid (1) to (5) requirements, the plurality of spaces 33 shown in Fig. 2 were formed inside the ACF 32.

These spaces are formed in the ACF when, in the heating and pressurizing processing, the viscosity of the adhesive rapidly decreases at the initial-process heating (process for approximately 0.1 to 0.5 second) so that a portion of the bonding layer flows out toward the exterior of the semiconductor device. The space rate to the ACF is

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Fig. 7 shows a modification of the method of making the spaces 33. The difference of this modification from the above-described embodiment shown in Fig. 2 is that, in addition to providing the spaces 33 between the bump strings 28, 29 in the longitudinal directions and between the bump strings 28, 28 in the transverse directions, the spaces 33 are formed between the respective bumps and outside the pair of bump strings. Even in the case of disposing the spaces 33 in this way, the connection of the semiconductor devices to the substrate can be maintained steadily. Incidentally, although Fig. 7 is illustrated with the bumps 28 and 29 omitted, bumps are formed around the end portions of the

Fig. 8 shows a modification of the bump arrangement. The difference of this modification from the above-described embodiment shown in Fig. 2 is that, instead of arranging the plurality of bumps 28, 29 to make a ring-like configuration, the bumps are disposed in rows only in the longitudinal directions. In this modification, a plurality of spaces 33 are provided between the bump strings 28, 29. However, instead of or in addition to these spaces, the spaces 33 can also be provided between the respective bumps and/or outside the bump strings.

For instance, the semiconductor connecting structure and the liquid crystal display unit according to this invention are applicable to various electronic apparatus other than a portable telephone, such as a navigation system, a television, a palm-top computer and an electronic

organizer, which require a visible information display.

Figs. 3 to 5 indicate the embodiments which this invention is applied to the COG (Chip On Glass) type liquid crystal display unit. However, this invention is also applicable to the other types of liquid crystal display units, for example, a COB (Chip On Board) type liquid crystal display unit.

Furthermore, in the embodiments shown in Figs. 3 to 5, the output terminal 6 on the portable telephone side as an electronic apparatus and the input terminal 21 on the liquid crystal panel 8 side are electrically connected to each other by the elastic connector 12. However, the connecting method for connecting both of them is not limited to this. For example, this invention includes a case of connecting both terminals by using an FPC (Flexible Printed Circuit).

Still further, in the embodiment shown in Fig. 1 the bonding layer 31 is constructed with the ACF 32 containing the conductive particles 34. Instead, it can be made by using an adhesive which does not contain conductive particles. In this case, spaces 33 are formed inside the adhesive. In addition, in this case, the bumps for the liquid crystal driving IC 7 are directly connected to the electrode terminals on the liquid crystal panel side.

CLAIMS

(1) A semiconductor device connecting structure for connecting a semiconductor device onto a substrate, characterized by comprising a bonding layer interposed between said semiconductor device and said substrate to accomplish adhesion therein, which includes a bonding material for adhering said semiconductor device onto said substrate and a space formed within said bonding material.

(2) A semiconductor device connecting structure as defined in claim 1, characterized in that said semiconductor device includes a plurality of bumps arranged in rows, and that said space is formed between said bump rows, outside said bump rows and between said bumps, or within at least one of areas therein.

(3) A semiconductor device connecting structure as defined in claim 1 or 2, characterized in that said space is constructed by placing a plurality of spaces closely to each other.

(9) A semiconductor device connecting method for connecting a semiconductor device onto a substrate, characterized by comprising the steps of:

interposing a bonding layer between said semiconductor device and said substrate to accomplish adhesion therein;

joining said substrate and said semiconductor device to each other by pressing a pressurizing head, heated up to a high temperature, against said semiconductor device to pressurize and heat said bonding layer; and

forming a space within said bonding layer.

(10) A semiconductor device connecting method as defined in claim 9, characterized in that said bonding material is made of an epoxy-based bonding material.

(11) A liquid crystal display unit comprising:

a pair of liquid crystal holding substrates disposed in an opposed relation to each other with liquid crystal between;

a semiconductor device connected onto at least one of said liquid crystal holding substrates; and

a bonding layer interposed between said liquid crystal

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(15) A liquid crystal display unit as defined in claim 11, characterized in that the rate of said space to said bonding material is 5% to 70%.

(16) A liquid crystal display unit as defined in claim 15, characterized in that the rate of said space to said bonding material is 10% to 30%.

(17) An electronic apparatus having a plurality of semiconductor driving output terminals and a liquid crystal display unit connected to said semiconductor driving output terminals, characterized in that said liquid crystal display unit includes:

a pair of liquid crystal holding substrates disposed in an opposed relation to each other with liquid crystal between;

a semiconductor device connected onto at least one of said liquid crystal holding substrates; and

a bonding layer interposed between said liquid crystal holding substrate and said semiconductor device to accomplish adhesion therein,

wherein said bonding layer includes a bonding material for adhering said semiconductor device onto said liquid

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crystal holding substrate and a space formed within said bonding material.

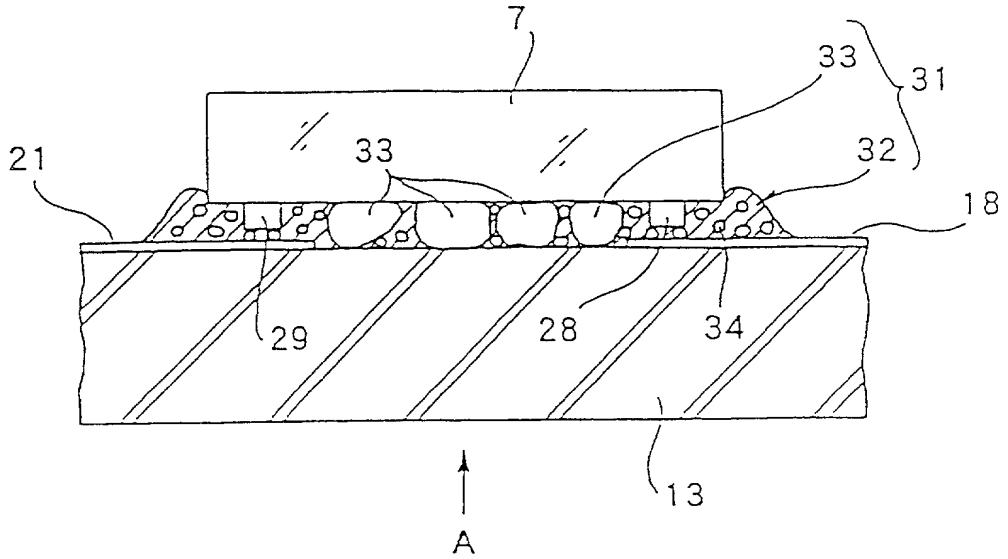
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ABSTRACT OF THE DISCLOSURE

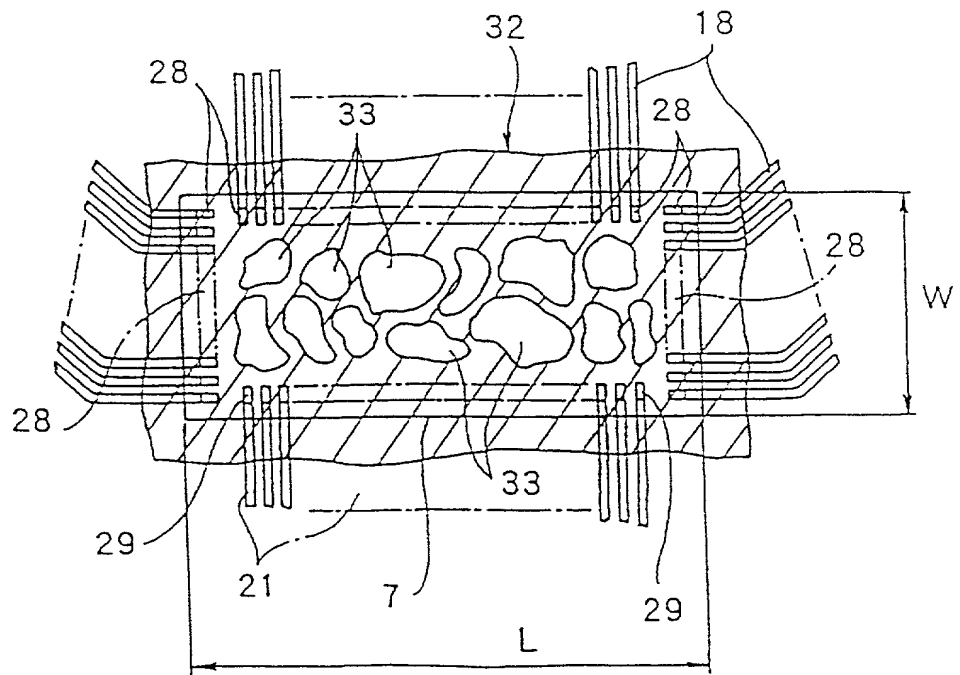
A semiconductor device connecting structure for connecting a semiconductor IC 7 onto a substrate 13. A bonding layer 31 is placed between the substrate 13 and the semiconductor IC 7 to accomplish adhesion therein. This bonding layer includes an ACF 32 as a bonding material for joining said semiconductor IC 7 onto said substrate 13 and a space 33 formed within the ACF 32. Even if the IC 7 deforms due to heat or the like, the deformation is absorbed by the space 33, whereupon the connecting conditions of bumps 28, 29 can not be unstable.

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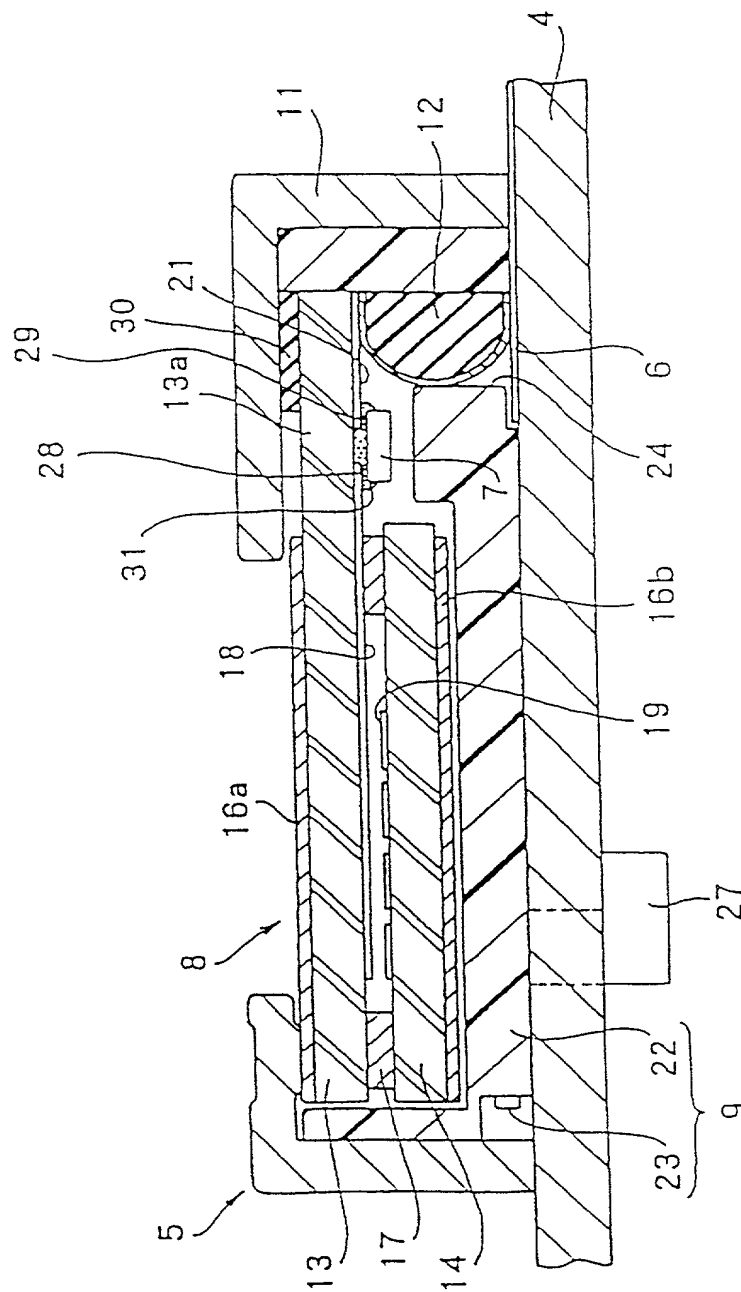
[FIG. 1]



[FIG. 2]

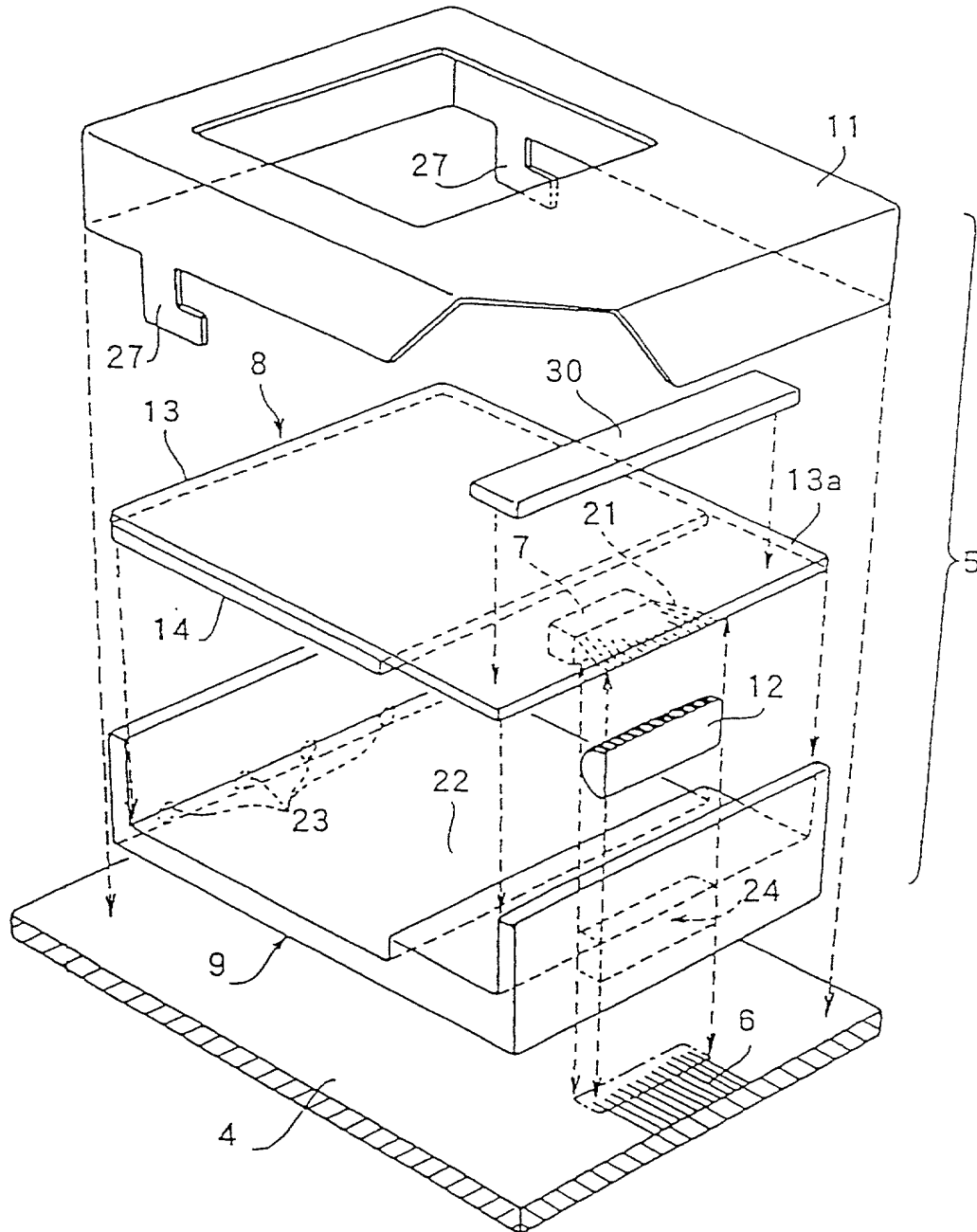


[FIG. 3]

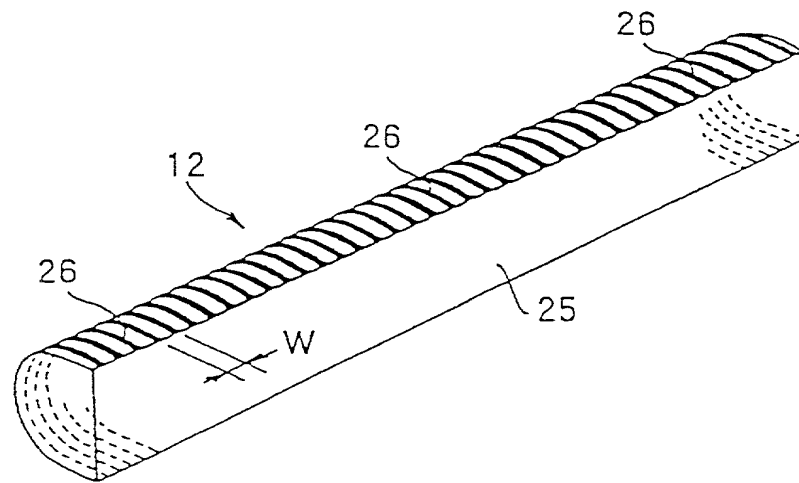


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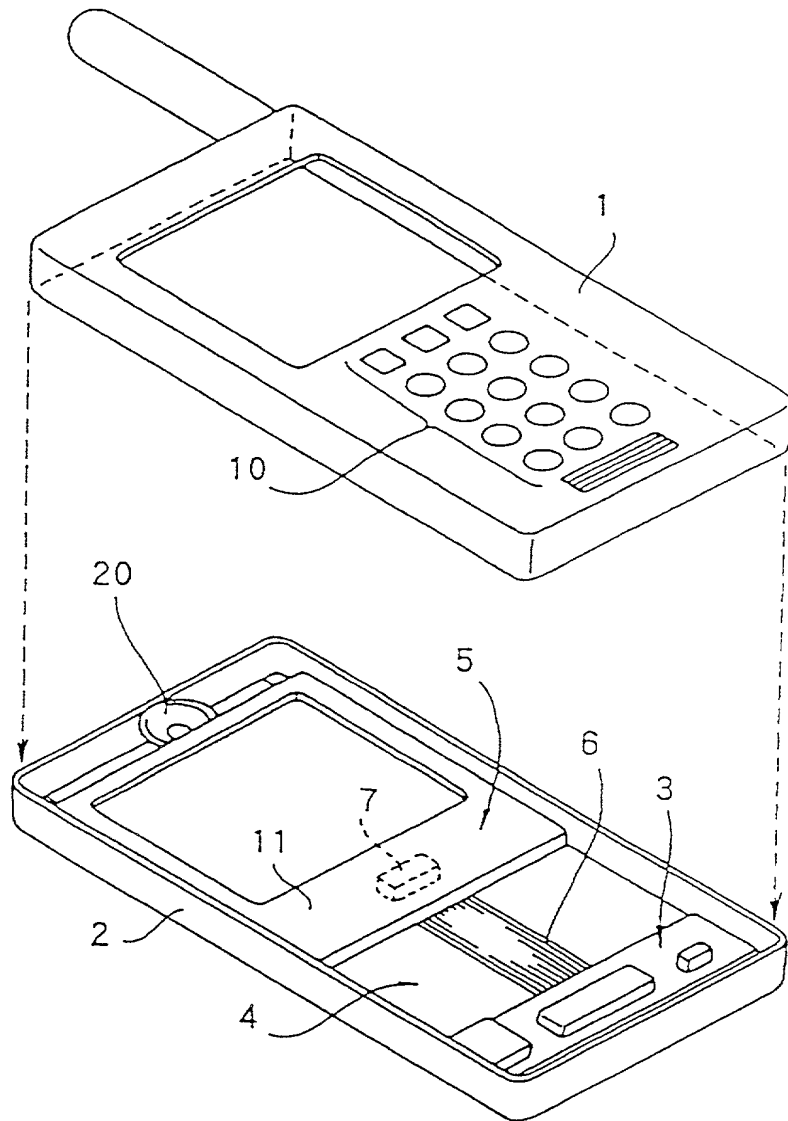
[FIG. 4]



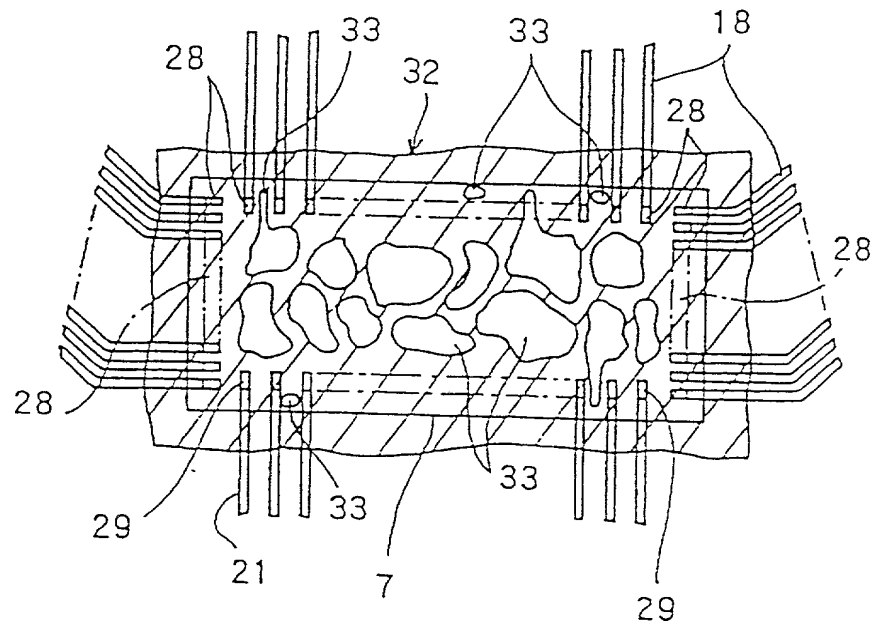
[FIG. 5]



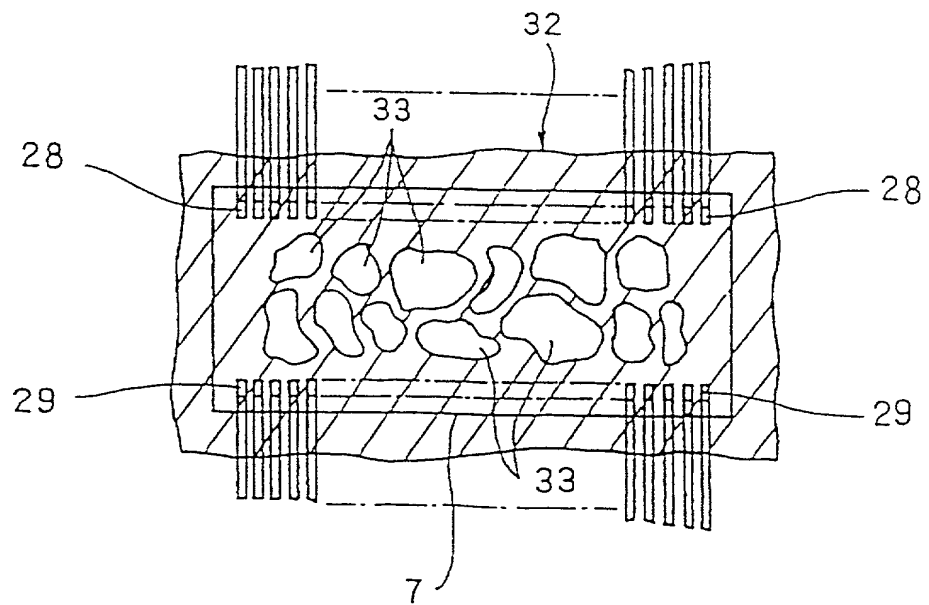
[FIG. 6]



[FIG. 7]



[FIG. 8]



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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

半導体素子の接続構造、その構造を用いた液晶表示装置及びそれを用いた電子機器Semiconductor Device Connecting Structure, Liquid Crystal Display Unit Based On The Same Connecting Structure, and Electronic Apparatus Using The Same Display Unit

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を _____ とし、
(該当する場合) _____ に訂正されました。☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

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I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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Prior Foreign Application(s)

外国での先行出願
8-235615

(Number) (番号)	(Country) (国名)
	Japan

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed
優先権主張なし

(Day/Month/Year Filed) (出願年月日)	
5/9/96	<input type="checkbox"/>

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(Application No.) (出願番号)	(Filing Date) (出願日)

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(Application No.) (出願番号)	(Filing Date) (出願日)

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(Application No.) (出願番号)	(Filing Date) (出願日)
PCT/JP97/03115	4/9/97

(Application No.) (出願番号)	(Filing Date) (出願日)

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(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)
Pending

(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

PTO/SB/106 (8-96)

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G. Gregory Schivley, Reg. No. 27,382, Bryant E. Wade, Reg. 40,344

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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(Supply similar information and signature for third and subsequent joint inventors.)

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